

**CLAIMS:**

1. A process for co-producing hydrocarbons and dimethyl ether (DME), the process including

5 feeding a gaseous feedstock comprising hydrogen and carbon monoxide, into a three-phase low temperature catalytic Fischer-Tropsch reaction stage;

allowing the hydrogen and carbon monoxide partially to react catalytically in the Fischer-Tropsch reaction stage to form hydrocarbons;

10 obtaining a tail gas from the Fischer-Tropsch reaction stage which includes unreacted hydrogen and carbon monoxide and also carbon dioxide;

adjusting the composition of at least a portion of the tail gas to provide a DME synthesis feedstock with a syngas number (SN) between 1.8 and 2.2, where

$$SN = \frac{[H_2] - [CO_2]}{[CO] + [CO_2]}$$

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$$\frac{[H_2] - [CO_2]}{[CO] + [CO_2]}$$

and where  $[H_2]$ ,  $[CO]$  and  $[CO_2]$  respectively are the molar proportions of hydrogen, carbon monoxide and carbon dioxide in the DME synthesis feedstock;

20 feeding the DME synthesis feedstock into a DME synthesis stage; and

converting at least a portion of the DME synthesis feedstock fed to the DME synthesis stage to DME.

2. The process as claimed in claim 1, in which the syngas number is between 25 1.85 and 2.15.

3. The process as claimed in claim 1 or claim 2, in which adjusting the composition of at least a portion of the tail gas from the Fischer-Tropsch reaction stage includes removing some  $CO_2$  from said portion of the tail gas, thereby adjusting the 30 syngas number upwardly.

4. The process as claimed in claim 3, in which removing some  $CO_2$  from said portion of the tail gas from the Fischer-Tropsch reaction stage includes absorbing the

CO<sub>2</sub> in a solvent, and recovering the removed CO<sub>2</sub>, by stripping the CO<sub>2</sub> from the solvent.

5. The process as claimed in claim 4, in which the CO<sub>2</sub> is stripped from the  
solvent with a methane-containing gas and in which the gaseous feedstock to the  
Fischer-Tropsch reaction stage is derived from the methane-containing gas.

6. The process as claimed in any one of the preceding claims, in which  
adjusting the composition of at least a portion of the tail gas from the Fischer-Tropsch  
10 reaction stage includes adding an H<sub>2</sub> rich gas to said portion of the tail gas.

7. The process as claimed in claim 6, in which adding an H<sub>2</sub> rich gas to said  
portion of the tail gas from the Fischer-Tropsch reaction stage includes reforming a  
portion of the gaseous feedstock to the Fischer-Tropsch reaction stage in a steam  
15 reforming stage to produce an H<sub>2</sub> rich reformed gas, and combining at least some of the  
H<sub>2</sub> rich reformed gas with said portion of the tail gas to provide the DME synthesis  
feedstock.

8. The process as claimed in claim 6, which includes removing an H<sub>2</sub> containing  
20 tail gas from the DME synthesis stage, recovering an H<sub>2</sub> rich gas from the DME  
synthesis stage tail gas, and adding said H<sub>2</sub> rich gas to the portion of the tail gas from  
the Fischer-Tropsch reaction stage to provide the DME synthesis feedstock.

9. The process as claimed in claim 6, in which adding an H<sub>2</sub> rich gas to said  
25 portion of the tail gas from the Fischer-Tropsch reaction stage includes subjecting a  
synthesis gas to the water gas shift reaction CO + H<sub>2</sub>O  $\rightleftharpoons$  CO<sub>2</sub> + H<sub>2</sub>, and removing at  
least some of the CO<sub>2</sub> to provide the H<sub>2</sub> rich gas, and combining at least some of the H<sub>2</sub>  
rich gas with said portion of the tail gas to provide the DME synthesis feedstock.

30 10. The process as claimed in any one of the preceding claims, in which some of  
the tail gas from the Fischer-Tropsch reaction stage is recycled to the Fischer-Tropsch  
reaction stage thereby to increase overall Fischer-Tropsch reaction stage CO and H<sub>2</sub>  
conversion to a value of between 30 % and 60 %.

11. The process as claimed in any one of the preceding claims, which includes treating the hydrocarbons to provide a naphtha fraction and/or a kerosene fraction.

12. The process as claimed in any one of the preceding claims, in which the  
5 Fischer-Tropsch reaction stage is operated at a temperature of less than 280 °C so that the liquid hydrocarbon product from the Fischer-Tropsch reaction stage comprises predominantly wax.

13. The process as claimed in any one of the preceding claims, which includes  
10 withdrawing liquid hydrocarbon products and gases and vapours from the Fischer-  
Tropsch reaction stage and cooling the gases and vapours to condense liquid  
hydrocarbons and reaction water present therein and in which a kerosene fraction of the  
condensed liquid hydrocarbons from the Fischer-Tropsch reaction stage is treated to  
remove oxygenated hydrocarbons and then alkylated and subjected to a separation  
15 stage to produce linear alkyl benzene, and optionally paraffins and oxygenates.

14. The process as claimed in any one of the preceding claims, in which  
converting at least a portion of the DME synthesis feedstock fed to the DME synthesis  
stage to DME includes contacting the DME synthesis feedstock with catalyst or  
20 catalysts that enhance methanol synthesis and methanol dehydration reactions, thereby  
to produce DME.

15. A process for co-producing a liquid fuel and light olefins, the process  
including  
25 co-producing liquid hydrocarbons and dimethyl ether (DME) from a gaseous  
feedstock comprising hydrogen and carbon monoxide;  
treating the liquid hydrocarbons to provide a liquid fuel; and  
converting at least some of the DME into light olefins.

30 16. The process as claimed in claim 15, in which the liquid hydrocarbons and the  
DME are co-produced in accordance with the process as claimed in any one of claims 1  
to 14 inclusive.

17. The process as claimed in claim 15 or claim 16, in which treating the liquid hydrocarbons to provide a liquid fuel includes subjecting at least a portion of the liquid hydrocarbons to hydroprocessing, thereby to produce lubricants and a diesel fraction, the liquid fuel produced thus being Fischer-Tropsch derived liquid fuel and including a  
5 diesel fraction.

18. The process as claimed in any one of claims 15 to 17 inclusive, in which the liquid hydrocarbons are also treated to produce a naphtha fraction and optionally a kerosene fraction, and in which at least some of the naphtha fraction and optionally  
10 some of the kerosene fraction are converted with at least some of the DME into light olefins.